Critical species of Odonata in southwestern Africa

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Abstract

In this report we review the conservation status of Odonata of southwestern Africa, viz Angola, Botswana, Namibia, Zambia and Zimbabwe. In total, 287 species have been recorded of which three have been previously listed by IUCN. We consider 60 species mainly because of their endemism in the region. The majority of the species have to be categorised as 'data deficient' according to IUCN regulations. The most important freshwater habitats in the region are the extensive swamps in the Kalahari basin, such as the Okavango Delta, the Caprivi swamps and the swamps along the courses of the middle Zambezi system, which host a unique odonate community. The most important threats for species in the region include overuse of water, construction of dams in the large rivers and deforestation. We strongly recommend extensive research on the Angolan and Zambian odonate faunas, which appear to be the richest in the regions, although they are poorly investigated.

Regional definition

We cover the following countries in southwestern Africa including adjacent landlocked African countries: Angola, Botswana, Namibia, Zambia, and Zimbabwe. Hence, from a perspective of freshwater biogeography we evaluated the species that occur in the major southwestern African drainage systems north of South Africa and south of the Congo (cf. Pallet 1997). This includes a number of international river basins (Table 1), namely Kunene, Okavango, upper Zambezi, Limpopo, and lower Orange. Several river systems are confined to only one country, such as the western catchments of Angola, including the large Cuanza River system, and the western catchments in Namibia, which terminate in the Atlantic Ocean. Clausnitzer (2004) considers Mozambique and Malawi, which partly includes

the lower Zambezi River system, while Samways (2004) reports on the Republic of South Africa (RSA) that covers the upper Orange River and southern Limpopo River systems.

The dominating biomes in the region are deciduous woodland and arid thornbush savannas and deserts (Kalahari in Botswana and Namibia; Namib and Karoo in Namibia). The lower reaches of the Linyanti-Chobe River, Zambezi River and Okavango River basin, particularly where the latter terminates in the Okavango Delta, as well as along the middle reaches of the Kafue River (Zambezi System) and at Lake Bangweulu consist of large swamp areas. Lakes (Lake Olweru, Lake Tanganyika) only occur along the northern border of Zambia, although very large impoundments (dams) are present on the Zambian/Zimbabwan border (Lake Kariba dam) and in Namibia (Hardap dam). Forest exists only in northern Angola and western Zambia, along perennial river courses in woodland savannas, and in deep ravines of the Angolan and Zimbabwean highlands. Most of the territory is on the African plateau at about 1,000 m a.s.l. and covered by deep sands of the Kalahari basin, e.g. the Okavango basin terminates in Kalahari sands, which are bordered to the east and the west by escarpments with higher mountains. The mountains do not reach into the African alpine biome, though some of these host or may host endemic species and subspecies, namely the Chimanimani Mts, the Iyanga Mts and the Vumba Mts along the border between Zimbabwe and Mozambique, the Planalto de Bié and the Serra da Chela in Angola and the Baynes Mts in Namibia.

State of the art

Studies on taxonomy, ecology and biodiversity

Pinhey (e.g. 1984a, 1984b, 1985; for Pinhey's bibliography see Martens in Vick et al. 2001) has done most work on Odonata in SW Africa. More recent research in Botswana and Namibia produced new checklists and identification keys, such as the work of Kipping (2003) in the Okavango Delta and Martens et al. (2003) in Namibia. No or very little recent work has been done in Angola, Zambia and Zimbabwe.

Studies on ecology and/or behaviour in the region are rare and ecological data are only available for the more common species. Some recent reviews deal with taxonomical problems (Dijkstra 2003), general ecology (Corbet 2003), ecology of desert species (Suhling et al. 2003), and reproductive behaviour (Martens 2003), including detailed information on species from SW Africa. Miller & Miller (2003) provided very detailed description of each species' ecology for a selection of species from eastern Africa, some of which also apply to SW Africa, while general reviews such as Corbet (1999) also apply. Extensive work has been done on habitat selection, larval and adult behaviour, life history, as well as on population and community ecology of some species that populate temporary pools in the Namibian western catchments (Padeffke & Suhling 2003; Johansson & Suhling 2004; Schenk et al. 2004; Suhling et al. 2004). The population structure and

Table 1. Major river basins in SW Africa, countries involved and common names of the rivers in the different countries.

River basin	Countries involved	Local names of the rivers or river sections
Cuanza R.	Angola	
Kunene R.	Angola, Namibia	Cunene
Zambezi R.	Angola, Botswana, Malawi, Mozambique, Namibia, Zambia, Zimbabwe	Zambeze
Okavango R.	Angola, Botswana, Namibia	Cubango, Kavango
Limpopo R. [1]	Botswana, Mozambique, RSA, Zimbabwe	
Orange R. [1]	Namibia, RSA	Oranje

[1] The Orange River and the Limpopo River form the borders of the region to the south and southeast and will be mainly considered by Samways (2004).

taxonomical relations of a number of species and genera from Namibia were investigated by molecular genetic methods (Giere 2002; Habekost 2002; Groeneveld 2003; Timm 2003). A spatial explicit population model for some species is under development (Braune 2004).

Identification guides

Reliable reviews exist for some genera and families: Chlorocyphidae (Pinhey 1967), Lestidae (Pinhey 1980a), *Aciagrion* (Pinhey 1972), *Agriocnemis* (Pinhey 1974), *Pseudagrion* (Pinhey 1964a), *Metacnemis* (Pinhey 1980b), *Chlorocnemis* (Pinhey 1969a), *Neurogomphus* (Cammaerts 2004), *Orthetrum* (Longfield 1955; Pinhey 1970a), *Trithemis* (Pinhey 1970b). Other genera such as *Gynacantha*, *Lestinogomphus* and *Phyllogomphus* are under revision (V. Clausnitzer, K.-D.B. Dijkstra and G. Vick in litt.). The key of Pinhey (1976) for the Odonata of Botswana is relevant as a basic key for the species of the region, although it needs updating. Tarboton & Tarboton (2002) recently published an illustrated booklet for South Africa on Anisoptera, which covers also most of the species of Botswana and Namibia. An updated identification key for Namibia is in preparation by the authors of this article, which will cover the majority of species of Botswana and southern Angola as well. A preliminary version is available from the authors.

African-wide keys for larvae are available for the genera *Anax* and *Aeshna* (Chelmick 1999, 2001) only. There are two preliminary illustrated larval keys to the families and the genera (for Central Africa: Chelmick 2000; for Namibia: Suhling et al. 2003). The illustrated key to the odonate larvae of Namibia, which also allows identification of several species, is available from the authors. Recently a key to the odonate larvae of South Africa was published (Samways & Wilmot 2003).

Faunal lists

Pinhey provided checklists for Botswana (Pinhey 1976) and for Zambia and Zimbabwe (Pinhey 1984b). The checklist of Botswana was recently updated by Kipping (2003) based on his own surveys from the Okavango basin and the Chobe River. Little recent data is available for Zambia and Zimbabwe (e.g. Lehmann & Wendler 1996). An Odonata checklist was included in a general freshwater animal checklist for Namibia (Curtis 1991), which has recently been revised and updated substantially (Martens et al. 2003) based on extensive surveys and data from several unreported collections, including those of the National Museum of Namibia in Windhoek and the Museum für Naturkunde in Berlin. Knowledge on Angola is limited to several collections examined by Ris (1931), Longfield (1947, 1955, 1959) and Pinhey (1961a, b, 1964b, 1965, 1975).

To date 287 species and seven additional subspecies in 73 genera have been recorded from southwestern Africa, with the species figures being 166 in Angola, 112 in Botswana, 110 in Namibia, 212 in Zambia and 156 in Zimbabwe. The species richness of Angola is expected to be widely underestimated as only minor parts of the country have been investigated. Odonata researchers rarely visited the north of Angola and, as far as we know, never visited the Cabinda region. However, the species numbers per country well reflect the humidity gradient from NE to SW (cf. Mendelsohn et al. 2002).

Critical species

Notes on some species previously listed by IUCN

Three species have been listed in the 1996 and 2003 Red Lists of threatened species (Moore 1997; IUCN 2003) for the region:

Aciagrion rarum
from Angola and Zambia as 'data deficient' (DD),
Eleuthemis buettikoferi quadrigutta
from Zimbabwe (DD),
Monarditheмis flava
from Angola and Zambia as 'vulnerable' (VU).

The identity of the ssp. *E. b. quadrigutta* is uncertain. It is only known from the female type and may well be a specimen of *E. buettikoferi* (K.-D.B. Dijkstra unpubl.), thus it should probably be removed from the list. K.-D.B. Dijkstra (pers. comm.) is preparing a taxonomical revision proposing that *Monarditheмis flava* belongs to the genus *Micromacromia*. *Ceriagrion mourae* from Mozambique (Clausnitzer 2004) and several species from South Africa (Samways 2004) are also listed that may occur in the region considered, but are not as yet recorded.

Species to be considered

In Table 2 we list species and subspecies that are endemic to the SW African region or are mainly confined to it. The latter means that sub-populations exist in neighbouring countries, for example a number of species are only known from NW Zambia, E Angola and from the Shaba region of the Democratic Republic of Congo (DCR). Other species seem to be confined to the lower Zambezi River in Zimbabwe and Mozambique.

Some species listed in Table 2 would probably not need special attention as they occur throughout the region and we consider them to be common, although supportive population data are currently not available. Most species from the region have to be listed as 'data deficient', which reflects the need of more research to clarify their conservation status through studies on distribution, habitat requirements and taxonomic position. Species listed in Table 2 are 'range restricted', where necessary measures can be at least roughly outlined, and/or 'data deficient' to such an extent that research is essential. The ecology of almost all species (cf. Table 2) is unknown. Some species, such as *Aethiothemis mediofasciata*, are only known from the type specimen. In some others revision is needed to resolve taxonomic problems (cf. Dijkstra 2003), e.g. *Onychogomphus kitchingmani* may be synonymous to *O. supinus* Hagen in Selys, 1854, and *O. quirki* synonymous to *O. styx* Pinhey, 1961 (K.-D.B. Dijkstra and V. Clausnitzer in litt.). If so, both have to be removed from the list. The taxonomy of some other species will change (K.-D.B. Dijkstra and V. Clausnitzer in litt.), which are marked accordingly in Table 2.

Table 2. Odonata endemic or mainly confined to the countries considered and their range of distribution in the region. Categories – DD: data deficient; RR: range restricted; IC: identity of species needs clarification; A: action recommended; because of habitat destruction. — Country codes: Ang: Angola; Bot: Botswana; DRC: Democratic Republic of Congo; Mal: Malawi; Moz: Mozambique; Nam: Namibia; RSA: Republic South Africa; Tan: Tanzania; Uga: Uganda; Zam: Zambia; Zim: Zimbabwe. Formerly listed species (IUCN 2003) are marked with an asterisk. Species, where the taxonomy will change are marked with a cross.

Familiy/species	DD	RR	IC	A	Distribution
Calopterygidae					
Umma distincta Longfield, 1933 †	●	○	●	○	Ang, Zam; also DRC (Shaba), Tan, Zim
femina Longfield, 1947	●	●	○	○	S Ang (e.g. Serra da Chela)
Chlorocyphidae					
Chlorocypha croceus croceus Longfield, 1947	●	○	○	○	Ang
croceus bamptoni Pinhey, 1975	●	●	●	○	Ang (only Serra da Chela)
rufitibia lucaluensis Pinhey 1967	●	○	●	○	N Ang
wittei Fraser, 1958	●	○	○	○	Ang, Zam; also DRC (Shaba)
Platycypha caligata angolense (Longfield, 1959)	●	●	●	○	S Ang (Serra da Chela)
fitzsimonsi inyangae Pinhey, 1958	●	●	●	○	Zim (Inyangae Mts)

Familiy/species	DD	RR	IC	A	Distribution
Coenagrionidae					
Aciagrion macrootithenae Pinhey, 1972	●	○	○	○	E Ang, NW Zam; also DRC (Shaba)
nodosum (Pinhey, 1964)	●	○	○	○	N and NW Zam
rarum (Longfield, 1947) *	●	○	○	○	E Ang, Central Zam
zambiense Pinhey, 1972	●	?	●	○	E Ang, NW Zam
Africallagma cuneistigma (Pinhey, 1969)	●	●	○	○	Zim (Chimanimani Mts.)
Agriocnemis angolensis Longfield, 1947	●	○	○	○	S Ang, Nam (Caprivi); ssp. *spatulae* Pinhey, 1974: Ang, NW Zam
ruberrima albifrons Balinsky, 1963	●	○	●	○	Bot
Ceriagrion katamborae Pinhey, 1961	●	○	○	○	Bot, Zam
sakejii Pinhey, 1963	●	○	○	○	N Zam; also DRC (Shaba)
Pinheyagrion angolicum (Pinhey, 1966)	●	○	○	○	Ang, Bot (Okavango), Zam; (swamps)
Pseudagrion angolense Selys, 1876	●	●	○	○	Ang
coeruleipunctum Pinhey, 1964	●	?	○	○	E Ang, Zam
deningi Pinhey, 1961	●	○	○	○	Bot, Nam (Caprivi), Zam
fisheri Pinhey, 1961	●	○	○	○	E Ang, Bot, Zam
greeni Pinhey, 1961	●	○	○	○	N Zam; also DCR (Shaba)
rufostigma Longfield, 1945	●	○	○	○	Ang, Bot, Zam
vumbaense Balinsky, 1963	●	●	○	○	E Zim (Vumba Mts.)
Protoneuridae					
Prodasineura flavifacies Pinhey, 1981	●	?	○	○	N Zam
Aeshnidae					
Aeshna moori Pinhey, 1981†	●	?	●	○	Zam (upper Zambezi catchment)
Anax bangweuluensis Kimmins, 1955	●	●	○	●	Bot (Okavango), Zam (Lake Bangweulu); (only swamps?)
Gomphidae					
Ictinogomphus dundoensis Pinhey, 1961	●	○	○	○	N Ang (Lake Calundo), Bot (Okavango), Nam (Kwando), N Zam (Lake Bangweulu); also DRC
Lestinogomphus sp. nov.	●	○	○	○	Bot; undescribed new species from the Okavango (Kipping 2003)
Microgomphus bivittatus Pinhey, 1961	●	○	●	○	N Ang (probably *Lestinogomphus*, V. Clausnitzer in litt.)
mozambicensis Pinhey, 1959	●	○	○	○	Zim; also Moz (lower Zambezi R.)
Neurogomphus cocytius Cammaerts, 2004	●	○	○	○	Zam, Zim
dissimilis Cammaerts, 2004	●	○	○	○	Zam, Zim; also Mal
zambesiensi Cammaerts, 2004	●	○	○	○	Zam, Zim; also Moz
Onychogomphus kitchingmani Pinhey, 1964	●	●	●	○	NW Zam (upper Zambezi R.)
quirkii Pinhey, 1964 †	●	○	●	○	N and NW Zam

Familiy/species	DD	RR	IC	A	Distribution
Gomphidae (continued)					
Paragomphus cataractae Pinhey, 1963	●	?	○	○	Nam (Okavango and Zambezi R.), Zam, Zim (middle Zambezi R.)
machadoi Pinhey, 1961	●	?	○	○	N Ang
zambeziensis Pinhey, 1961	●	○	○	○	Zim (middle Zambezi R.)
Phyllogomphus dundomajoricus Fraser, 1957 †	●	?	●	○	N Ang; also DCR, Uganda
Corduliidae					
Phyllomacromia paludosa Pinhey, 1976 †	●	○	●	○	Bot, Zam, Zim
unifasciata Fraser, 1954	●	○	○	○	N Ang, Zam; also DRC (Shaba)
Libellulidae					
Aethiothemis mediofasciata Ris, 1931 †	●	○	●	○	S Ang; the sp. is known from the female type only, which may also belong to *A. solitaria*
Congothemis leakyi (Pinhey, 1956)	●	○	○	○	Zam, Zim
Crocothemis brevistigma Pinhey, 1961	●	○	○	○	NW and N Zam
Eleuthemis buettikoferi quadrigutta (Pinhey, 1974) *†	●	●	●	○	Zim (Vumba Mts.); only known from female type; this may be just a nominate form female of *E. buettikoferi*
Lokia ellioti Lieftinck, 1969	●	○	○	○	Zam
Malgassophlebia bispina longistipes Pinhey, 1964 †	●	?	●	○	NW Zam
Micromacromia flava (Longfield, 1947) *	●	?	○	○	S Ang, Zam; listed as *Monardithemis flava*
Neodythemis fitzgeraldi Pinhey, 1961	●	?	○	○	N Zam
Nesciothemis fitzgeraldi Pinhey in Longfield, 1955	●	○	○	○	NW and N Zam
Porpax risi Pinhey, 1958	●	○	○	○	Ang, Zam, Zim; also Moz and Mal
Rhyothemis mariposa Ris, 1913	●	○	○	○	Ang, Bot, Nam, Zam; also DRC (Shaba)
Trithemis aequalis Lieftinck, 1969	●	○	○	○	Bot, Nam (Caprivi), Zam
anomala Pinhey, 1956	●	○	○	○	N and NW Zam; also DRC (Shaba)
brydeni Pinhey, 1970	●	?	○	●	Bot (Okavango), Zam (L. Bangweulu); (only 3 records from swamps in total)
'Okavango', near *stictica*	●	○	●	○	Bot, Nam (Caprivi); molecular genetics of the Okavango population of *T. stictica* differ widely from other populations, it may be a new ssp. or a new sp. (Giere 2002)
Zygonyx atritibiae Pinhey, 1961	●	○	●	○	Ang, Zam; also DRC

Critical sites and threats

Enough information is available only for a few species to determine habitat requirements and conservation measurements. The suggested measures in this chapter are therefore not species specific, but concentrate on areas, which, at the present state of knowledge, contain endangered species or highly isolated and therefore vulnerable populations. Many of the protective measures for aquatic sites in general, as listed by Clausnitzer (2004), are relevant to SW Africa as well.

Wetlands in general

Wetlands are generally poorly protected and the important biological resources in these ecosystems are rapidly being lost through clearance and overuse. Some wetland areas, however, are protected in national parks and nature reserves, e.g. parts of the Okavango Delta in Botswana, parts of the Linyanti-Chobe and Okavango swamps in Namibia, and parts of the Zambezi and Kafue floodplains in Zambia. Improved conservation through draft national policies on wetlands in Namibia and Botswana, as well as multinational basin management commissions (already established for the Okavango, Zambezi, Kunene, and Orange basins), can be expected in future.

Rapids and waterfalls are under severe threat by plans to construct dams for electric power plants, e.g. at Epupa Falls at the Kunene River and at Popa Falls at the Okavango River. *Paragomphus cataractae* appears to be confined to rapids and waterfalls of large rivers. It was originally described from Victoria Falls (cf. Pinhey 1984b) and has only recently been recovered at the Zambezi rapids at Katima Mulilo and the Okavango rapids of Popa Falls, both Namibia. The species is vulnerable because of its habitat limitation and will be threatened if dams will destroy the rapids.

A major problem of wetlands in the arid parts of the region is overuse of water by people. Some of the ephemeral Namibian rivers contain large dams in the upper courses to supply water to nearby towns. On one hand, these reservoirs create new habitats for Odonata, though on the other they prevent water from reaching downstream habitats and result in a considerable increase in evaporation. Additional dams, particularly in perennial rivers for electricity generation and flow regulation, e.g. in the Kunene, Orange, Okavango, and Zambezi are under discussion. Some new methods of water storage are already being practiced: the Omaruru Delta dam is situated in the lower course and stores water in the sediment of the river bed, which reduces evaporation (Jacobsen et al. 1995).

Riverine forests are an important habitat for many odonate species, which need shade, e.g. Calopterygidae: *Umma*, some Gomphidae and Tetrathemistinae: *Eleuthemis*. In the middle courses of the Okavango, Chobe, and Kunene this type of forest is limited as extensive floodplains and swamps dominate. Where present, the riparian forests are under considerable pressure by people for wood and clearing of land for villages and agriculture (e.g. Mendelsohn & el Obeid 2004). Deforestation along the rivers leads to habitat fragmentation, which is a severe problem as fragmented populations may easily die out. The few remaining riparian forests are in urgent need of protection.

Another case of habitat fragmentation occurs in the arid parts of Namibia. Several otherwise widespread African species as *Pseudagrion kersteni* (Gerstäcker, 1869), *Trithemis stictica* (Burmeister, 1839) and *Anax speratus* Hagen, 1867 occur only in some few streams (≤ 10 localities each). In the past, all these species may have been more common, but many springs and streams, e.g. at the Waterberg and in the Otavi Mountains, have been destroyed by extraction of groundwater for irrigation (e.g. Barnard 1998). Recent research showed that the single sub-populations of *P. kersteni* and *A. speratus* are genetically homogenous (Groeneveld 2003; Timm 2003), which implies that the sub-populations went through bottlenecks and that there is probably no or little genetic exchange with populations elsewhere. Re-colonization of such sites from source populations elsewhere is therefore unlikely.

Water pollution appears to be a very local problem at present because the human population in most parts of the region is still low (but see below). However, pesticides used in agriculture and against human pest vectors (e.g. Tsetse fly) are an emerging problem in the wetland areas. Currently little is known about the effects of these pesticides on Odonata in the region. Studies of Muirhead-Thomson (1973, 1987) on some stream species, namely *Pseudagrion kersteni*, *Crocothemis divisa* Karsch, 1898, *Crocothemis sanguinolenta* (Burmeister, 1839) and *Zygonyx torridus* (Kirby, 1889), indicate that these species are highly susceptible to several pesticides tested. In contrast, *Aeshna* larvae in the Cape region (probably *A. minuscula* McLachlan, 1896) did not suffer from organophosphate insecticides in microcosms (Schulz et al. 2001). River salination due to agriculture, as described for RSA (Flügel 1995), or flow limitations due to dam construction, may alter the assemblages because many Odonata are not salt tolerant (Suhling et al. 2003).

The occurrence of fish as main predators of larvae (Johnson 1991; Stoks & McPeek 2003) affects Odonata assemblages in general. Although there are few such studies on African Odonata (but see Weir 1972), the introduction of fish, particularly of foreign species (e.g. Nile Perch *Lates niloticus* or Carp *Carpinus carpio*) to wetlands, may have major effects on Odonata assemblages. Within fish assemblages such effects are already reported from Namibia where the introduction of the Namibian endemic *Tilapia guinasana* (in order to protect its localised population) caused the local extinction of another endemic fish, *Pseudocrenilabrus philander*, in Lake Otjikoto (Barnard 1998).

Swamps

The large swamp areas in the Kalahari basin are probably the most outstanding freshwater habitats for Odonata in the region, but also the less investigated. Some species seem to be confined to the large swamp areas, namely the Okavango Delta, the swamps in the Caprivi and around Lake Bangweulu, and probably several other swamps in Zambia (e.g. Barotse floodplains, Kafue flats). *Anax bangweuluensis* and *Trithemis brydeni* have only been encountered in the Okavango Delta in Botswana and at or near Lake Bangweulu in Zambia. *Ictinogomphus dundoensis* is known from the upper Zambezi River swamps in Angola, from the Lake

Bangweulu area and the Okavango Delta; very recently it has been recorded at the swampy Kwando River in Namibia. During an Odonata inventory of the Okavango Delta in 2001 and 2002 (Kipping 2003) none of these 'swamp species' has been encountered. The Odonata of the Okavango Delta are threatened by such aerial spraying of organophosphate pesticides against tsetse fly, although the effects of aerial spraying on Odonata populations have not yet been studied. The Caprivi and Okavango swamps in Namibia are under severe pressure by comparatively high human population densities (cf. Mendelsohn & el Obeid 2004). Similar pressures can be expected in neighbouring countries.

Mountain ranges

High mountain ranges provide important habitats to some of the critical species (Table 2) and several species endemic to these mountains. The Chimanimani, Vumba and Inyanga Mountains at the Zimbabwe-Mozambique border host the endemics *Platycypha fitzsimonsi inyangae* and *Africallagma cuneistigma*. Though a national reserve exists in the Chimanimani Mountains, the status of endemic Odonata and wetlands in that park is currently unclear. Although rainfall is very limited in the southwestern part of the region, the high mountain ranges of Namibia and Angola have several permanent small watercourses and springs (e.g. Jacobson et al. 1995). These are inhabited by endemic species as well as highly isolated populations of species occurring in South Africa. The Serra da Chela, SW Angola, hosts the endemics *Umma femina*, *Chlorocypha croceus bamptoni*, and *Platycypha caligata angolense*. Though part of the Iona National Park, the current situation of odonate habitats in the Serra da Chela is unknown to us and should be investigated. *Aeshna minuscula*, which is mainly confined to RSA, has been re-corded near the Otavi Mountains of Namibia in the early 20th century and recently the Naukluft Mountains, Namibia (Martens et al. 2003). The Naukluft Mountains in Namibia are situated in a secure protected area (Namib-Naukluft Park), though the populations in the Otavi Mountains are most likely extinct.

Large river catchments

Zambezi River: Several species listed in Table 2 occur along the Zambezi, and some species are only known from very distinct sections of that system. Several species seem to be confined to the upper Zambezi catchment, i.e. to E Angola and NW Zambia (Mwinilunga), although some (may) also occur in the upper Congo catchment. Examples are *Chlorocypha wittei*, *Prodasineura flavifacies* and *Onychogomphus kitchingmani*. To our knowledge no surveys have been done since Pinhey's visit in 1964 (Pinhey 1964). *Paragomphus zambeziensis* may be restricted to the middle Zambezi (Pinhey 1984b). There is no information about the recent situation of Odonata below Lake Kariba, which may affect odonate assemblages of the lower Zambezi. An inventory along the Zambesi is required, with special reference to major tributaries such as the Kafue and Luangwa subsystems.

Kunene River: The Kunene River catchment hosts some species and subspecies

endemic for the region, e.g. those occurring in the Serra da Chela (see above) and there may be more. Six species listed in Table 2 are known from this basin, but knowledge about the Odonata of the Kunene River is poor, particularly of the floodplains along the upper Kunene (Angola). The lower course of the Kunene River is heavily affected by the Ruacana hydroelectrical plant, which causes daily water-level fluctuation of one meter below the Ruacana diversion weir (Barnard 1998). Another dam is planned at Epupa falls for electricity generation (Simmons et al. 1993). The effects of the Ruacana hydroelectrical plant on the odonate assemblage of the lower Kunene River remain unknown, as only a few collections are available (see Martens et al. 2003), most of which dates from after the establishment of the weir. However, it is known that the water level fluctuations caused extinctions and major changes in the fish assemblage of the lower Kunene River and the same may be true for the Odonata. Hence, it would probably be of benefit to reduce the fluctuations, e.g. by building upstream dams that help to regulate the water level, as was originally planned. There is no information available from the extensive floodplains along the middle and upper reaches of the Kunene system.

Okavango River: A number of species listed in Table 2 occur in the Okavango catchment (see also swamps). The fringes of the Okavango River in Namibia are widely deforested except for some small patches, e.g. the Popa Falls Nature Reserve. Populations of species, which need riverine forests, have been severely affected by this deforestation. We know nothing about the situation of the Okavango River and its major tributaries, e.g. the Cuito, in Angola. For the Okavango Delta in Botswana see the chapter Swamps.

W and N Angolan river systems: Very little information is available about the odonates of the river systems comprising the western catchments in Angola, except of some records from the Cuanza River system (Longfield 1959; Pinhey 1965). A number of species listed in Table 2 has been recorded at rivers in the Dundo area, which belong to the Congo River system, such as *Paragomphus machadoi*, and *Phyllogomphus dundomajoricus* synonym *dundominusculus*. There is no recent information from all these river systems, which may be particularly rich in species.

Conservation priorities and recommendations

It is of major importance to improve public awareness of the importance and functioning of wetlands, both to local populations inhabiting river, lake and wetland margins, as well as policy makers and officials implementing management decisions. Information boards on Odonata should be prepared for information centres in protected areas, tourist establishments and schools. Illustrated keys are urgently needed to allow local people with the opportunity to study odonates and, therefore, to contribute to the knowledge on the fauna in the region. For Namibia keys for adult and larval odonates are in preparation, while webpages will allow people to obtain current information on the topic. A poster was printed to make people familiar with odonates.

Research priorities

The immediate problem concerning odonate diversity assessment in the region is data deficiency on species distribution, ecology and systematics. Political instability, e.g. in Angola and Zimbabwe, hinders any kind of fieldwork. The lack of trained people in the region, e.g. there are no professional or amateur odonatologists in any of the countries reported here, has the result that no sustainable research programme can be established. In addition, though water-related research and monitoring is regarded as critical in all these countries, technicians and hydrologists have very little recourse to information on the odonates of the region and their relevance to the management of aquatic ecosystems. Though the recent field guide on South African Anisoptera (Tarboton & Tarboton 2002) has provided a desperate need, it has to be upgraded and expanded considerably if it is to provide in the need for such a guide for the whole region. In order to establish a more reliable information system, the research needed is probably the same all over Africa (Clausnitzer 2004):

— Systematic revisions
— Inventories
— Development of data for Angola, Zambia and Zimbabwe since Pinhey (1984b)
— Collection of ecological data for range restricted species

Species listed as 'data deficient' in Table 2 as well as sites listed in the text should get priority in future research on Odonata. We would like to suggest that Angola deserves special attention, which is poorly surveyed and yet as the most heterogeneous range of odonate habitats in the region. The large rivers, extensive swamps and lakes in Zambia also deserve attention.

Current activities

The main current activities in the region were based in Namibia around the BIOTA (Biodiversity Transect Analysis in Africa) research project titled "Diversity of Namibian dragonflies: effects of anthropogenic changes on wetlands and modelling on different geographical scales" supported by German Ministry of Science and in cooperation with the National Museum of Namibia, Windhoek. Several ecological questions have been investigated and surveys in Namibia are continuing (see above). An electronic database for the odonates of Namibia is in preparation and will soon be available. This may serve as a basis for an Africa-wide database. Researchers of the NMNW and BIOTA will also start survey activities in Angola and probably in Zambia in near future.

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